METHOD FOR MANUFACTURING LIQUID INJECTING HEAD

BACKGROUND OF THE INVENTION

Field of the Invention

The present invention relates to a method for manufacturing a liquid injecting head used with a liquid injecting system for injecting liquid from a liquid discharge nozzle as a liquid droplet.

Related Background Art

A liquid injecting head used with a liquid injecting system (ink jet system) includes a plurality of liquid discharge nozzles for discharging liquid such as ink, liquid supply paths communicated with the respective liquid discharge nozzles, and discharge energy generating elements (for example, electrical/thermal converting elements) associated with the respective liquid discharge nozzles so that, by applying a drive signal corresponding to discharge information to the discharge energy generating element to afford discharge energy to liquid within the liquid discharge nozzle associated with the discharge energy generating element, the liquid is discharged from a minute discharge port of the liquid discharge nozzle as a flying liquid droplet, thereby effecting the recording.

As liquid discharge heads of this kind and nozzle members therefor, various techniques have been

proposed, and various manufacturing method therefor have also been proposed. Now, an example of the conventional liquid discharge head and nozzle member therefor will be described with reference to Figs. 11 and 12. Fig. 11 is a view showing a liquid discharge head and a nozzle member disclosed in Japanese Patent Application Laid-open No. 6-31918 (1994), for example, wherein a nozzle member 101 is formed from a silicon wafer cut and polished to have a surface having crystal <100> face. The nozzle member includes a through opening 102 for supplying liquid and liquid discharge nozzles 103. A heater board (element substrate) 105 comprises silicon chips on which plural electrical/thermal converting elements (referred to as "heaters" hereinafter) 106 as discharge energy generating elements are provided. The nozzle member 101 and the heater board 105 are joined or adhered to each other so that the nozzles 103 are opposed to the heaters 106, and thin or fine nozzles each having a triangular cross-section are defined between the nozzles 103 and a surface of the heater board 105, and the heaters 106 are included in the respective nozzles 103.

The nozzle member 101 is manufactured as follows. That is to say, an inorganic film made of SiO_2 is formed on the surface of the silicon wafer constituting the nozzle member 101 by a film forming method such as

thermal oxidation of CVD, and resist material of an organic film is formed on the nozzle surface by a spin-coat method. Then, patterning corresponding to shapes of the nozzles 103 and the through opening 102 is effected, and, thereafter, anisotropical wet etching is effected while immersing the nozzle member into etching liquid such as KOH or TMAH. As a result, the etching growths along <111> face of silicon, and, when the silicon wafer having the surface of <100> face is used, since the <111> face is inclined by 54.7 degrees with respect to the surface, the nozzles 103 and the through opening 102 are formed as shapes as shown in Figs. 11 and 12.

When the liquid injecting head is formed by joining or adhering the nozzle member 101 formed in this way to the heater board 105, since there remains a wall portion 110 between the nozzles 103 and the through opening 102 in the nozzle member 101, flow paths for liquid cannot be reserved. To reserve such flow paths, as shown in Fig. 12, flow path walls 107 are formed on the heater board 105 by patterning polyimide material, thereby reserving liquid supply paths as shown by the arrow 108.

In the liquid injecting head shown in Figs. 11 and 12, liquid such as ink is supplied from a liquid tank (not shown) and is directed into the through opening 102 as the liquid supply path and reaches the nozzles

103 through the aforementioned liquid supply paths. The plurality of heaters 106 provided on the heater board 105 are controlled a control circuit (not shown) so that the heater 106 is selectively energized in response to recording information. The heater 106 energized in response to the recording information generates heat to heat the liquid within the corresponding nozzle 103, and the heated liquid is boiled when exceeds a certain critical temperature, thereby forming a bubble. Due to increase in volume caused by the formation of the bubble, a part of the liquid is forcibly pushed out from the nozzle 103 to fly onto a recording medium such as paper. By repeating such operations, a recorded image is completed.

In the above-mentioned conventional technique, by using the silicon wafer having the surface of <100> face as the nozzle member, although there is provided advantages that a depth can be adjusted by configuration of patterning since the etching grows obliquely and that the nozzles and the through opening can be formed by single etching, as shown in Fig. 12, since the wall portion 110 remains between the nozzles 103 and the through opening 102, the flow path walls 107 must be formed on the heater board 105 by patterning the polyimide material to reserve the liquid supply paths shown by the arrow 108 in Fig. 12, which

makes manufacturing processes of the heater board complicated.

Further, since the shape of each nozzle 103 has the triangular cross-section as shown in Fig. 11, a wall thickness between the nozzles 103 is increased, which worsens efficiency for forming the nozzles and affects a bad influence upon high density arrangement of nozzles.

Furthermore, in the liquid injecting head in which the heaters are used as the discharge energy generating elements, to solve a problem that a force of the bubble for discharging the liquid escapes through the through opening, as shown in Fig. 13, there has been proposed a method in which a valve 109 is provided above each heater 106 to enhance the liquid discharging efficiency. That is to say, the valve 109 serves to be moved upwardly by the bubble force when the bubble is generated by the heating of the heater 106 and to prevent the bubble from escaping toward the through opening 102. However, in the case there the nozzle 103 has the triangular cross-section, when the valve 109 is moved upwardly, the valve is apt to be contacted with the walls of the nozzle 103, and, in order to prevent the valve 109 from contacting with the walls of the nozzle, a nozzle width must be increased excessively, which affects a bad influence upon the high density arrangement of nozzles.

Further, there have also been proposed methods for nozzles by working material other than silicon, and, according to such methods, although there is provided an advantage that the nozzles can be formed as free configurations by using resin and the like, when the number of nozzles is increased to lengthen the recording head, due to difference in thermal expansion rate between the nozzle member and the heater board, good adhesion between the nozzle member and the heater board cannot be achieved, which leads in limitation of the dimension length of the liquid injecting head.

SUMMARY OF THE INVENTION

The present invention is made in consideration of the above-mentioned conventional drawbacks, and an object of the present invention is to provide a method for manufacturing a liquid injecting head, in which a liquid injecting head suitable for high density arrangement of nozzles and suitable for lengthening the head can be manufactured by forming a plurality of nozzles each having a rectangular cross-section by effecting anisotropical etching on a member in which liquid discharge nozzles are to be formed.

To achieve the above object, according to the present invention, there is provided a method for manufacturing a liquid injecting head, in which liquid flow paths are defined by combining an element

substrate having a plurality of discharge energy generating elements for applying discharge energy to liquid with a nozzle member having a plurality of liquid discharge nozzle grooves, which method comprises a step for preparing at least one material common to the element substrate as a base material of the nozzle member, a step for forming etching mask layers on a first surface of the base material of the nozzle member in which the nozzle grooves are formed and a second surface opposite to the first surface, a step for forming a recessed portion in the second surface of the base material by patterning the mask layer on the second surface of the base material and by effecting etching via the mask layer of the second surface, and a step for forming the nozzle grooves in the base material and for communicating the recessed portion with the nozzle grooves by patterning the mask layer on the first surface of the base material and by effecting etching via the mask layer of the first surface and the mask layer of the second surface.

In the liquid injecting head manufacturing method according to the present invention, it is preferable that a silicon wafer having a surface of <110> face is used as the material of the nozzle member.

In the liquid injecting head manufacturing method according to the present invention, it is preferable that an etching amount t of anisotropical etching for

forming the recessed portion satisfies a relationship $tw > t > tw - tn$ when it is assumed that a thickness of the nozzle member (silicon wafer) is tw and a depth of the nozzle groove is tn, and, in the manufacturing method in which the nozzle grooves and a liquid chamber are formed simultaneously by anisotropical etching, it is preferable that an etching amount t of anisotropical etching for forming the liquid supply paths satisfies a relationship $tw > t > tw - 2 \times tn$ when it is assumed that a thickness of the nozzle member (silicon wafer) is tw and a depth of the nozzle groove is tn.

According to the liquid injecting head manufacturing method of the present invention, high density arrangement of nozzles can be permitted, and an elongated liquid injecting head can easily be manufactured.

Further, an elongated high density liquid injecting head can stably be manufactured without increasing alignment accuracy of patterning.

Furthermore, by forming the nozzle member by using the same silicon as the heater board, distortion due to heat does not occur between the nozzle member and the heater board, with the result good adhesion between the nozzle member and the heater board can be maintained and the liquid injecting head can be made longer.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a schematic perspective view of a liquid injecting head manufactured in accordance with a first embodiment of a liquid injecting head manufacturing method of the present invention;

Figs. 2A, 2B and 2C are views showing a nozzle member constituting the liquid injecting head manufactured in accordance with the first embodiment of the present invention, where Fig. 2A is a plan view of the nozzle member looked at from a nozzle forming surface side, Fig. 2B is a side view of the nozzle member, and Fig. 2C is a sectional view taken along the line 2C-2C in Fig. 2A;

Figs. 3A, 3B, 3C, 3D, 3E, 3F and 3G are views showing manufacturing steps for the nozzle member according to the first embodiment of the present invention;

Figs. 4A, 4B, 4C, 4D, 4E, 4F and 4G are views showing manufacturing steps for a nozzle member according to an alteration of the first embodiment of the present invention;

Fig. 5 is a sectional view of a liquid injecting head in which a valve for improving discharge efficiency is added to the liquid injecting head manufacturing in accordance with the first embodiment of the present invention;

Fig. 6 is a schematic perspective view of a liquid injecting head manufactured in accordance with a second

embodiment of a liquid injecting head manufacturing method of the present invention;

Figs. 7A, 7B and 7C are views showing a nozzle member constituting the liquid injecting head manufactured in accordance with the second embodiment of the present invention, where Fig. 7A is a plan view of the nozzle member looked at from a nozzle forming surface side, Fig. 7B is a side view of the nozzle member, and Fig. 7C is a sectional view taken along the line 7C-7C in Fig. 7A;

Figs. 8A, 8B, 8C, 8D, 8E, 8F and 8G are views showing manufacturing steps for the nozzle member according to the second embodiment of the present invention;

Figs. 9A, 9B, 9C, 9D, 9E, 9F and 9G are views showing manufacturing steps for a nozzle member according to an alteration of the second embodiment of the present invention;

Fig. 10 is a sectional view of a liquid injecting head in which a valve for improving discharge efficiency is added to the liquid injecting head manufactured in accordance with the second embodiment of the present invention;

Fig. 11 is a schematic perspective view of a conventional liquid injecting head;

Fig. 12 is a schematic perspective view of the liquid injecting head shown in Fig. 11; and

Fig. 13 is a schematic sectional view of a liquid injecting head in which a valve for improving discharge efficiency is added to the liquid injecting head shown in Fig. 11.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

The present invention will now be explained in connection with embodiments thereof with reference to the accompanying drawings.

Fig. 1 is a schematic perspective view of a liquid injecting head manufactured in accordance with a first embodiment of a liquid injecting head manufacturing method of the present invention, and Figs. 2A to 2C are views showing a nozzle member constituting the liquid injecting head manufactured in accordance with the first embodiment of the present invention, where Fig. 2A is a plan view of the nozzle member looked at from a nozzle forming surface side, Fig. 2B is a side view of the nozzle member, and Fig. 2C is a sectional view taken along the line 2C-2C in Fig. 2A.

In Fig. 1 and Figs. 2A to 2C, a nozzle member 1 is formed from a silicon wafer having a surface of <110> face, and the nozzle member 1 is provided with a through opening 2 as a liquid supply path for supplying liquid, and a plurality of liquid discharge nozzles (or nozzle grooves) 3 and is joined or adhered to an element substrate (referred to as "heater board"

hereinafter) 5 on which a plurality of heaters 6 as discharge energy generating elements are provided.

The through opening 2 and the nozzles 3 are formed to have rectangular cross-sections by effecting anisotropical etching by using the silicon wafer having the surface of <110> face as material of the nozzle member 1, which cross-sections are different from triangular or trapezoidal cross-sections of the conventional nozzles and through opening. By using the nozzle member 1 in which the nozzles 3 have the rectangular cross-section in this way, since a wall thickness between the nozzles 3 can be thinned, high density arrangement of nozzles 3 can easily be realized, and, since the nozzles 3 and the through opening 3 are interconnected within the nozzle member 1, it is not required that liquid supply paths be reserved by forming walls on the heater board 5. That is to say, unlike to the conventional case, when the nozzle member 1 is closely joined to the heater board 5 having no special flow path members made of polyimide and liquid is supplied from a liquid tank (not shown) into the through opening 2, the nozzles 3 are filled with the liquid by a capillary phenomenon, and, when the heater 6 on the heater board 5 is energized under the control of a control circuit (not shown), the liquid is bubbled and is discharged from a discharge port at an end of the nozzle 3.

Next, a method for manufacturing the nozzle member 1 will be fully described.

In general, it is known that, when silicon is subjected to wet etching by using etching liquid such as TMAH or KOH, an anisotropical etching phenomenon in which etching grows along <111> crystal face occurs. If such wet etching is effected on the silicon wafer having the surface of <100> face, since the <111> face is inclined by 54.7 degrees with respect to the <100> face, the shapes as described in connection with the conventional technique will be obtained. However, in case of the silicon wafer having the surface of <110> face, since the <111> face is perpendicular to the surface, the nozzles having vertical walls as shown in Figs. 1 and 2A to 2C can be formed.

In this case, however, since the longer the etching time the greater a depth of a groove (ultimately forming a through hole), the depth of the groove cannot be controlled by the mark configuration, unlike to the conventional case. That is to say, the nozzles and the through opening cannot be formed by single etching, and, thus, patterning of mask and etching of silicon must be effected two times. Although the depth of the nozzle is varied in dependence upon density of nozzles, since the nozzle depth is generally 10 µm to several hundreds of µm, for example, if the nozzles are firstly formed, although

the nozzles must be protected by coating resist on the nozzles when the through opening is formed, it is difficult to coat the resist on the nozzles uniformly, thereby arising a problem regarding the protection of the nozzles. On the other hand, if the through opening is firstly formed, the patterning of nozzle surface will become very difficult.

Now, manufacturing steps for the nozzle member according to a first embodiment will be explained with reference to Figs. 3A to 3G.

In Fig. 3A, a silicon (Si) wafer 10 constituting material for the nozzle member has a surface of <110> face. As shown in Fig. 3B, films 11, 12 of silicon dioxide (SiO_2) are formed on both surfaces of the silicon wafer 10 by a film forming method such as thermal oxidation or CVD. Incidentally, the silicon dioxide serves as a mask layer when the silicon is subjected to anisotropical etching. Then, as shown in Fig. 3C, patterning corresponding to the shape of the through opening is effected on the SiO_2 film 11 opposite to the nozzle forming surface by a normal photo-lithography technique. Then, the anisotropical etching is effected while immersing the wafer into etching liquid such as TMAH. The etching grows from the patterning portion, thereby forming a deep hole 2a, as shown in Fig. 3D. In this case, it is important that the hole does not become a through hole by controlling

the etching condition. Namely, if the hole 2a becomes the through hole and only the thin SiO_2 film 12 remains on the nozzle forming surface, it is impossible to maintain the wafer surface at the nozzle forming surface side flat, with the result that it becomes difficult to effect resist coating and exposure in the next nozzle formation. Thus, it is important that the silicon remains by a small thickness smaller than a depth of the nozzle. That is to say, an etching amount t of the anisotropical etching has a value satisfying a relationship tw > t > tw - tn when it is assumed that a thickness of the silicon wafer (nozzle member) is tw and a depth of the nozzle 3 is tn.

Then, resist material (not shown) is coated on the SiO_2 film 12 at the nozzle forming surface side, and patterning corresponding to the nozzle configuration is effected by dry etching (Fig. 3E). In this case, as mentioned above, since the nozzle forming surface side is kept flat, the coating of the resist material and the patterning corresponding to the nozzle configuration can be performed easily. Then, by immersing the silicon wafer into anisotropical etching liquid again, the nozzle portion is etched and, at the same time, etching for the holes 2a is continued from the opposite side. As a result, when the nozzle 3 is formed, the hole 2a reaches the nozzle forming surface to form the through opening 2 communicated with the

nozzle 3 (Fig. 3F). Lastly, by removing the SiO_2 films 11, 12 remaining on both surfaces of the silicon wafer 10, a nozzle member having the nozzle 3 and the through opening 2 as shown in Fig. 3G is completed.

Next, an alteration of the nozzle member manufacturing steps according to the illustrated embodiment will be explained with reference to Figs. 4A to 4G. In this alteration, steps shown in Figs. 4A to 4D are the same as the aforementioned steps shown in Figs. 3A to 3D. Further, in the step shown in Fig. 3E, while the dry etching was effected when the patterning of the SiO_2 film 12 was performed, this alteration differs from the illustrated embodiment in that, in a step shown in Fig. 4E, wet etching is effected. That is to say, while the SiO_2 film 11 was remained on the surface opposite to the nozzle forming surface in the step shown in Fig. 3E, in the step shown in Fig. 4E, such a film 11 is removed. The reason is that, since the SiO_2 film 11 on the surface opposite to the nozzle forming surface is once subjected to the patterning for formation of the through opening and thus it is difficult to coat the resist thereon to protect the film, when the silicon wafer is immersed into the etching liquid in order to effect the patterning of the SiO_2 film 12 at the nozzle forming surface side, the SiO_2 film 11 on the surface opposite to the nozzle forming surface is etched simultaneously. Accordingly,

in the anisotropical etching for formation of the nozzle (Fig. 4F), at the same time when the nozzle is formed, silicon at the opposite side is also etched. However, this opposite side does not relate to the discharge property directly, and, since it is important that the liquid from the liquid tank (not shown) be supplied without leakage, even when the nozzle member is totally thinned more or less, there is no problem regarding function. In this way, in this alteration, the wet etching is effected as the patterning of silicon dioxide, thereby enhancing the productivity.

Further, in the first embodiment and the alteration thereof according to the present invention, since the same silicon as the heater board is used as the material of the nozzle member, even when the number of nozzles is increased to make the liquid injecting head longer, the adhesion (close contact) between the nozzle member and the heater board is maintained and distortion due to heat does not occur.

Furthermore, the nozzle member in the first embodiment and the alteration thereof according to the present invention is also effective when a valve is provided in the nozzle to enhance the discharging efficiency. That is to say, as shown in Fig. 5, in a case where a valve 9 is provided above the heater 6, since the nozzle 3 has the rectangular cross-section, when the valve 9 is moved upwardly, the valve does not

contact with the walls of the nozzle 3. Thus, since a width of the nozzle 3 may be slightly greater than a width of the valve 9, high density arrangement of nozzles can be achieved while maintaining high discharging efficiency.

Next, a second embodiment of a liquid injecting head manufacturing method according to the present invention will be explained with reference to Figs. 6 to 10. Fig. 6 is a schematic perspective view of a liquid injecting head manufactured in accordance with a second embodiment of a liquid injecting head manufacturing method of the present invention, and Figs. 7A to 7C are views showing a nozzle member constituting the liquid injecting head manufactured in accordance with the second embodiment of the present invention, where Fig. 7A is a plan view of the nozzle member looked at from a nozzle forming surface side, Fig. 7B is a side view of the nozzle member, and Fig. 7C is a sectional view taken along the line 7C-7C in Fig. 7A.

In Fig. 6 and Figs. 7A to 7C, a nozzle member 21 is formed from a silicon wafer having a surface of <110> face, and the nozzle member 21 is provided with a through opening 2 as a liquid supply path for supplying liquid, a plurality of liquid discharge nozzles (or nozzle grooves) 23 and a liquid chamber 24 (refer to Fig. 7A) for reserving the liquid to stably supply the

liquid into the nozzles 23 and is joined or adhered to a heater board 25 on which a plurality of heaters 26 as discharge energy generating elements are provided.

The through opening 2, nozzles 3 and liquid chamber 24 are formed to have rectangular cross-sections by effecting anisotropical etching by using the silicon wafer having the surface of <110> face as material of the nozzle member 1. In general, it is known that, when silicon is subjected to wet etching by using etching liquid such as TMAH or KOH, etching grows along <111> crystal face. Since the <111> face is perpendicular to the <110> face, the nozzles having vertical walls as shown in Figs. 6 and 7A to 7C can be formed. Further, by forming the liquid chamber 24 by anisotropical etching simultaneously with the nozzles 23, although a depth of the liquid chamber is substantially the same as depths of the nozzles 23, since the liquid chamber does not have walls such as those of the nozzles, the depth of the liquid chamber becomes slightly greater than the depths of the nozzles.

Next, manufacturing steps for the nozzle member according to the second embodiment will be explained with reference to Figs. 8A to 8G.

In Fig. 8A, a silicon (Si) wafer 30 constituting material for the nozzle member has a surface of <110> face. As shown in Fig. 8B, films 31, 32 of silicon

dioxide (SiO_2) are formed on both surfaces of the silicon wafer 30 by a film forming method such as thermal oxidation or CVD. Then, as shown in Fig. 8C, patterning corresponding to the shape of the through opening is effected on the SiO_2 film 31 opposite to the nozzle forming surface by a normal photo-lithography technique. Then, the anisotropical etching is effected while immersing the wafer into etching liquid such as TMAH. The etching grows from the patterning portion, thereby forming a deep hole 22a, as shown in Fig. 8D. In this case, it is important that the hole does not become a through hole by controlling the etching condition. Namely, if the hole 22a becomes the through hole and only the thin SiO_2 film 32 remains on the nozzle forming surface, it is impossible to maintain the wafer surface at the nozzle forming surface side flat, with the result that it becomes difficult to effect resist coating and exposure in the next nozzle formation. Thus, the silicon layer remains by such as amount that the wafer surface at the nozzle forming surface side can be kept flat. That is, the silicon layer having a thickness smaller than twice of a depth of the nozzle, as will be described later.

Then, resist material (not shown) is coated on the SiO_2 film 32 at the nozzle forming surface side, and patterning corresponding to configurations of the nozzle 23 and the liquid chamber 24 is effected by dry

etching (Fig. 8E). In this case, since the nozzle forming surface side is kept flat, the coating of the resist material and the patterning corresponding to the configurations of the nozzle and the liquid chamber can be performed easily. Then, by immersing the silicon wafer into anisotropical etching liquid again, the nozzle and liquid chamber portions are etched and, at the same time, etching for the holes 22a is continued from the opposite side. As a result, when the nozzle 23 is formed, the hole 22a reaches the nozzle forming surface to form the through opening 22 communicated with the nozzle 23 through the liquid chamber 24 (Fig. 8F). In this case, since the liquid chamber portion does not have the wall such as the wall of the nozzle, the etching speed of the liquid chamber becomes greater than that of the nozzle, and, thus, the depth of the liquid chamber becomes slightly greater than the depth of the nozzle. Here, regarding a relative position of the through opening 22 with respect to the liquid chamber 24, since it is important that the liquid chamber 24 is merely communicated with the through opening 22, so long as the through opening 22 sufficiently smaller than the dimension of the liquid chamber 24, the alignment accuracy is not required to be severe. By forming the nozzle 23 and the liquid chamber 24 simultaneously, the length of the nozzle can be reserved and the through opening 22 can surely be

communicated with the liquid chamber 24. Further, at an area where the through opening 22 is communicated with the liquid chamber 24, since the etching grows from both sides, the thickness of the silicon to be remained (not to form the hole 22a as the through opening) in the anisotropical etching step shown in Fig. 8D can be made smaller than twice of the depth of the nozzle. That is to say, an etching amount t of the anisotropical etching may have a value satisfying a relationship $tw > t > tw - 2 \times tn$ when it is assumed that a thickness of the silicon wafer (nozzle member) 30 is tw and the depth of the nozzle 23 is tn.

In this way, in the second embodiment, a problem that the nozzles may not be communicated with the through opening due to mis-alignment caused when the patterning is effected on both surfaces of the silicon wafer to form the nozzles 23 and the through opening 22 respectively, and a problem that the lengths of the nozzles are reduced due to excessive overlap can be eliminated.

After the nozzles 23, liquid chamber 24 and through opening 22 were formed in this way, by removing the SiO_2 films 31, 32 remaining on both surfaces of the silicon wafer 30, the nozzle member as shown in Fig. 8G is completed.

By using the nozzle member manufactured in accordance with the second embodiment, since a wall

thickness between the nozzles can be thinned, high density arrangement of nozzles can easily be realized, and, since the nozzles and the through opening are interconnected within the nozzle member, it is not required that liquid supply paths be reserved by forming walls on the heater board. That is to say, as shown in Fig. 6, when the nozzle member 21 is closely joined to the heater board 25 having no special flow path members made of polyimide and liquid is supplied from a liquid tank (not shown) into the through opening 22, the nozzles 23 are filled with the liquid through the liquid chamber 24 by a capillary phenomenon. Further, since the correct nozzle length can be reserved without increasing the alignment accuracy of the patterning on both surface, the stable liquid discharging can always be performed. Incidentally, although the rectangular grooves can be formed by dry etching in the nozzle forming step shown in Fig. 8F, wet etching is preferable in consideration of productivity.

Next, an alteration of the nozzle member manufacturing steps according to the illustrated embodiment will be explained with reference to Figs. 9A to 9G. In this alteration, steps shown in Figs. 9A to 9D are the same as the aforementioned steps shown in Figs. 8A to 8D. Further, in the step shown in Fig. 8E, while the dry etching was effected when the patterning

of the SiO_2 film 32 was performed, this alteration differs from the illustrated embodiment in that, in a step shown in Fig. 9E, wet etching is effected. That is to say, while the SiO_2 film 31 was remained on the surface opposite to the nozzle forming surface in the step shown in Fig. 8E, in the step shown in Fig. 9E, such a film 31 is removed. The reason is that, since the SiO_2 film 31 on the surface opposite to the nozzle forming surface is once subjected to the patterning for formation of the through opening and thus it is difficult to coat the resist thereon to protect the film, when the silicon wafer is immersed into the etching liquid in order to effect the patterning of the SiO_2 film 32 at the nozzle forming surface side, the SiO_2 film 31 on the surface opposite to the nozzle forming surface is etched simultaneously. Accordingly, in the anisotropical etching for formation of the nozzle (Fig. 9F), at the same time when the nozzle is formed, silicon at the opposite side is also etched. However, this opposite side does not relate to the discharge property directly, and, since it is important that the liquid from the liquid tank (not shown) be supplied without leakage, even when the nozzle member is totally thinned more or less, there is no problem regarding function. In this way, in this alteration, the wet etching is effected as the patterning of silicon dioxide, thereby further enhancing the

productivity.

As mentioned above, also in the second embodiment and the alteration thereof according to the present invention, high density arrangement of nozzles can be realized, and, since the same silicon as the heater board is used as the material of the nozzle member, even when the number of nozzles is increased to make the liquid injecting head longer, the adhesion (close contact) between the nozzle member and the heater board is maintained and distortion due to heat does not occur. Further, the nozzle member in the second embodiment and the alteration thereof according to the present invention is also effective when a valve is provided in the nozzle to enhance the discharging efficiency. That is to say, as shown in Fig. 10, in a case where a valve 29 is provided above the heater 26, since the nozzle 23 has the rectangular cross-section, when the valve 29 is moved upwardly, the valve does not contact with the walls of the nozzle 23. Thus, since a width of the nozzle 23 may be slightly greater than a width of the valve 29, high density arrangement of nozzles can be achieved while maintaining high discharging efficiency.

As mentioned above, according to the present invention, since the vertical nozzle walls can be formed by using the silicon as the material of the nozzle member of the liquid injecting head, an

elongated liquid injecting head having high density arrangement of nozzles can easily be manufactured.

Further, by manufacturing the nozzle member by using the same silicon as the heater board, distortion due to heat between the nozzle member and the heater board can be prevented, with the result that the close contact between the nozzle member and the heater board can be maintained, thereby providing an elongated liquid injecting head.